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(56) Documents cited
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(58) Field of search
UK CL (Edition J) G1C
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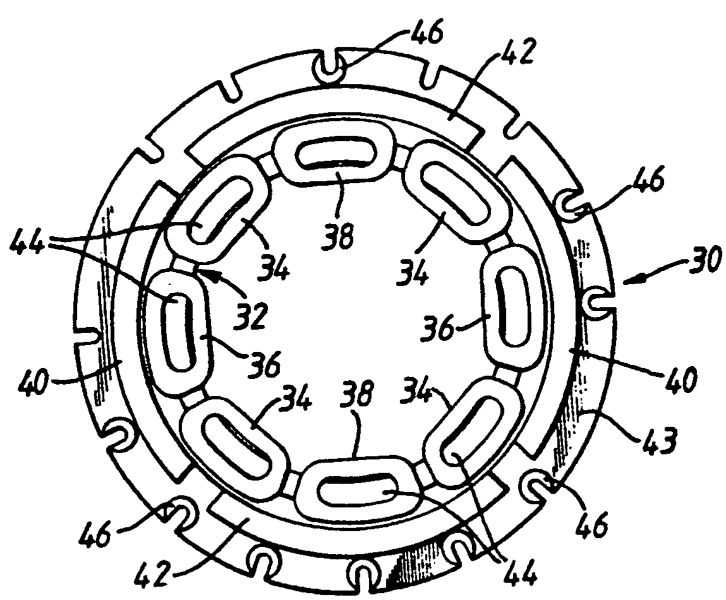
(54) Dynamically tuned gyroscopes

(57) A dynamically tuned gyroscope includes a combined pick-off and torquer assembly. The assembly comprises an integrally formed pick-off support means (32) of castellated ring form having pole pieces (44); a plurality of preformed primary (34) and secondary (36; 38) pick-off coils mounted on said pole pieces; a plurality of torquer coils (40; 42); and a printed circuit board (43) having terminals (46) for the free ends of the coils or groups of coils (34, 36, 38).



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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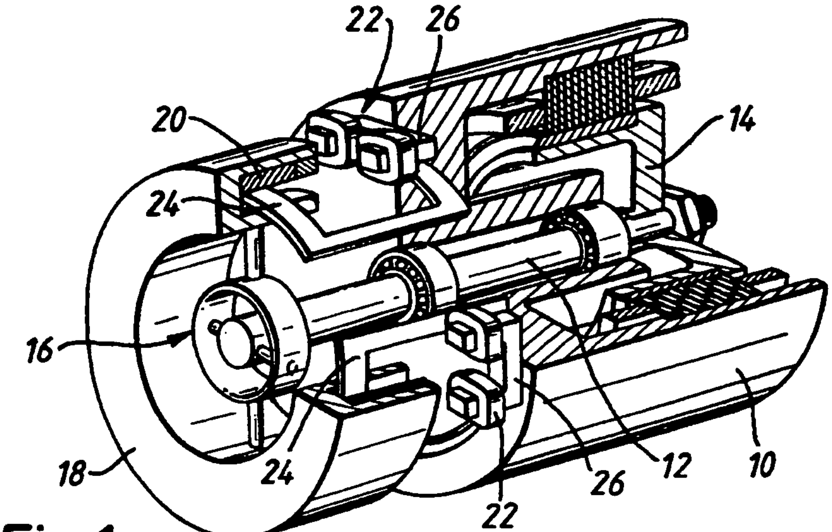
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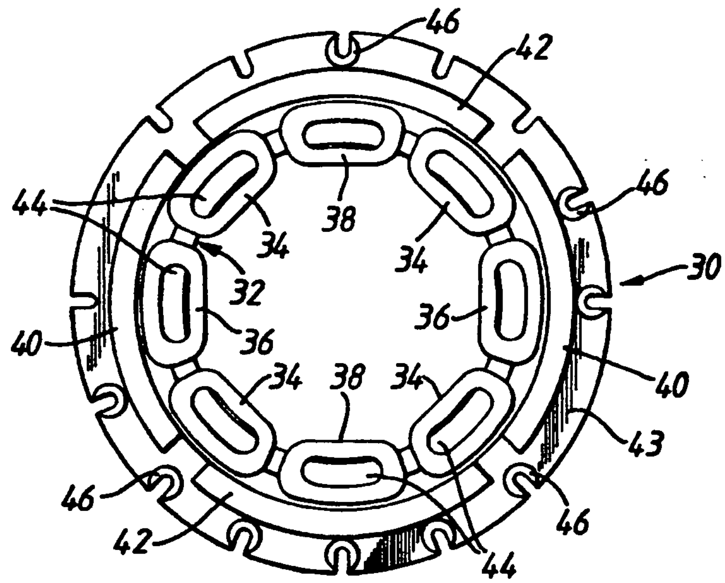
Fig. 1.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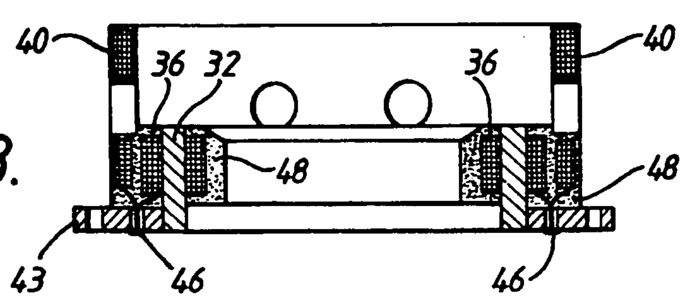
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Fig. 3.

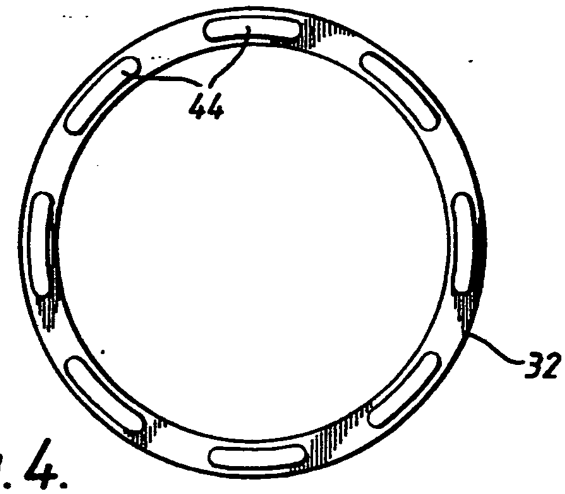

Fig. 4.

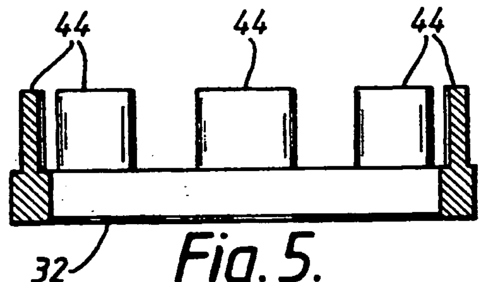

Fig. 5.

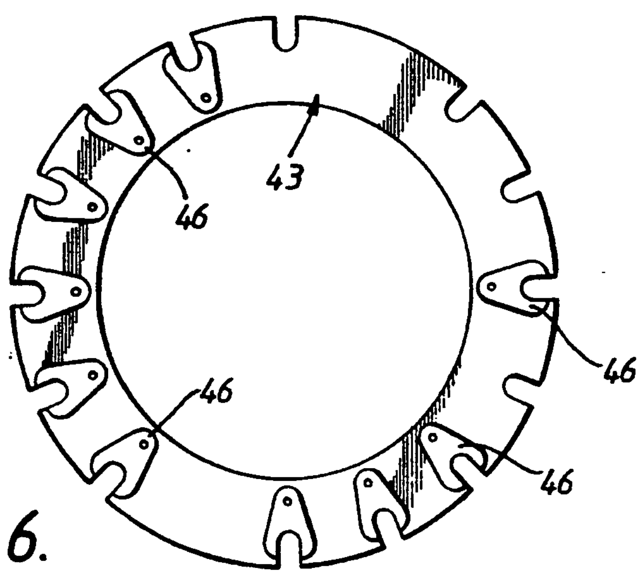

Fig. 6.

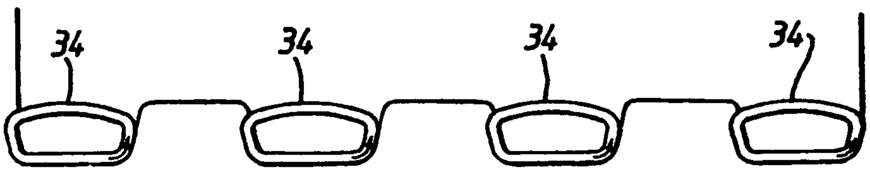

Fig. 7.

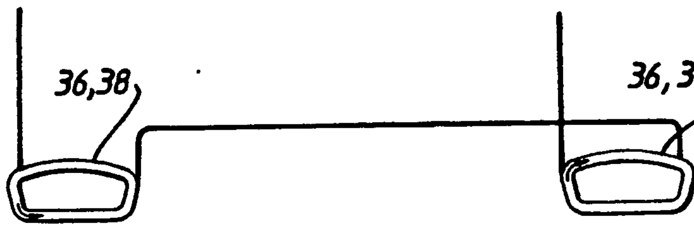

Fig. 8.

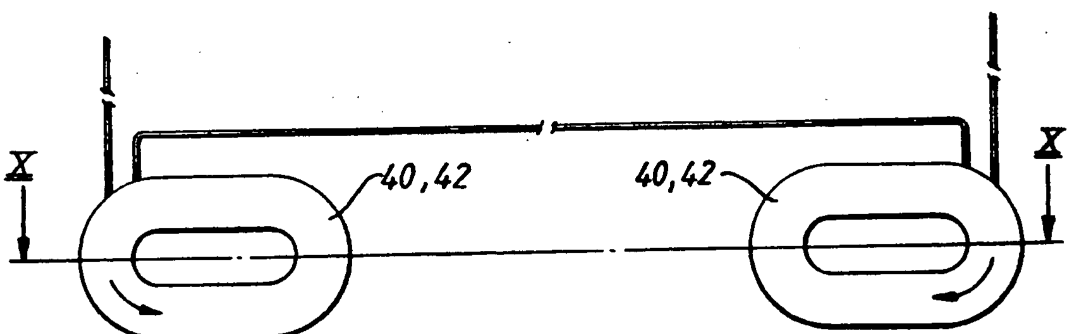

Fig. 9.

Fig. 10.

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DYNAMICALLY TUNED GYROSCOPES

This invention relates to dynamically tuned gyroscopes and methods of construction thereof.

In a dynamically tuned gyroscope the gyro rotor is capable of tilting about two axes orthogonal to the spin axis. When the gyro is subjected to angular movement about one or both of the orthogonal axes, a torque is generated which tends to tilt the rotor away from its equilibrium position. The dynamically tuned gyroscope has sensors in the form of pick-off coils which sense movement of the rotor away from its equilibrium position. The pick-off coils may be configured as a differential transformer. The output from the pick-off coils is processed to provide an input signal for a pair of 'X' and 'Y' torquer coils which provide a compensatory torque which maintains the rotor in its equilibrium position. The data from the pick-off coils is also processed to provide positional data, for example the rate and direction of angular movement of the gyroscope casing.

Such gyroscopes are typically employed in strap-down inertial navigation systems but also find applications in many other areas. For many applications it is desirable that the gyroscope is as small as possible.

The pick-off coils and torquer coils of dynamically tuned gyroscopes normally consist of individual coils mounted on individual laminated cores which are then attached separately by hand to the main body of the gyroscope. This method of manufacture leads to poor null stability, especially when the gyroscope is subjected to fluctuating temperatures. Also, in the existing method, the accurate positioning and the fine wiring of several small components by hand leads to high production costs and poor reliability.

According to one aspect of this invention there is provided a dynamically tuned gyroscope including:

a rotor mounted for spinning about a spin axis; and

a position detector for detecting tilting movement of the rotor about axes orthogonal to said spin axis; said detector comprising a pick-off support means having a generally ring-shaped main body portion integrally formed with a plurality of pole piece portions projecting

therefrom at spaced portions around the main body portion, each of said pole piece portions facing said rotor and having associated therewith a respective coil.

According to another aspect of this invention there is provided a method of making a dynamically tuned gyroscope including a rotor mounted for spinning about an axis and a position detector for detecting tilting movement of the rotor about axes orthogonal to said spin axis, which method includes the steps of:

integrally forming a pick-off support means having a ring-shaped main body portion and a plurality of pole piece portions projecting therefrom at spaced positions around the main body portion;

preforming a plurality of coils; and

assembling said coils on said pole piece portions to provide said position detector.

The embodiments of the invention disclosed herein are believed to provide a separate sub-assembly which can be produced in large quantities and be fully environmentally tested before assembly to the main body of the gyroscope. Stability may be improved in the disclosed embodiments by the use of a single component for the iron core of the part of the sub-assembly that provides the cores on which the pick-off coils are located. The disclosed embodiment of sub-assembly also includes a printed circuit board to which the ends of the pick-off and torquer coils are attached during preliminary testing. By this arrangement the necessity to handle fine wires when attaching the sub-assembly to the main body is eliminated.

The invention will now be described by way of non-limiting example, reference being made to the accompanying drawings, in which:-

Figure 1 is a part cut away perspective view of an example of a known dynamically turned gyroscope;

Figure 2 is an end view on the gyro pick-off and torquer assembly of an example of dynamically tuned gyroscope of this invention with the potting omitted;

Figure 3 is a diametrical section view through the gyro pick-

off and torquer assembly of Figure 2 with the potting in place;

Figure 4 is an end view on a pick-off support of the assembly of Figures 2 and 3;

Figure 5 is a diametrical section view through the pick-off support of Figure 4;

Figure 6 is an end view on a printed circuit board of the assembly of Figures 2 and 3;

Figure 7 is a plan view of the preformed primary pick-off coils of the assembly of Figures 2 and 3;

Figure 8 is a plan view of one of the two pairs of the preformed secondary pick-off coils of Figures 2 and 3;

Figure 9 is a plan view of two of the torquer coils of the assembly of Figures 2 and 3; and

Figure 10 is a section view taken on lines X-X of Figure 9.

Referring to Figure 1 a dynamically tuned gyroscope includes a casing 10 which rotatably supports a rotor shaft 12 which carries at one end the rotor 14 of an electric drive motor. The other end of the rotor shaft 12 carries, by means of a two axis gimbal arrangement 16, a gyro rotor 18. The gyro rotor 18 is thus capable of compound tilting movement about two axes orthogonal to the rotor shaft. The gyro rotor is of ferromagnetic material and carries a permanent magnet ring 20. In use, tilting movement of the rotor is sensed by pick-off coils 22 and the output from the coils is processed to generate a compensating torque which is generated by means of the torquer coils 24.

In existing arrangements, the pick-off coils 22 and the torquer coils 24 have been separately wound and assembled by hand with the pick-up coils being located on discrete pole piece elements 26.

Referring now to Figures 2 and 3, there is illustrated a pick-off and torquer assembly 30 which comprises a pick-off support 32, four primary pick-off coils 34, two X-axis secondary coils 36, two Y-axis secondary coils 38, two X-axis torquer coils 40, two Y-axis torquer coils 42 and a printed circuit board 43 providing terminals for the various coils and groups of coils.

The pick-off support 32 is a castellated ring with individual castellations 44 defining pole pieces for the pick-off coils 34, 36, 38. The castellated pick-off support 32 is manufactured using electrodischarge machining techniques from the material known as Radiometal 4450. This manufacturing process is beneficial to the production of this component as it results in burr-free surfaces that do not damage the wire insulation of the pick-off coils as they are assembled.

The pick-off coils 34, 36, 38 are manufactured using wire with a self-bonding resin coating. The coils are wound onto a former then heated by passing an electric current through the wire. This activates the resin coating which subsequently cures to bond adjacent turns together to provide sufficient rigidity to enable removal of the coils from the winding former without distortion. The coils are then positioned on the appropriate castellations 44 of the pick-off support 32.

It will be understood that the pick-off support 32 includes eight castellations 44; alternate castellations support primary coils 34, whilst of the remaining intermediate castellations one diametrically opposed pair support the X-axis secondary coils 36 and the other diametrically opposed pair support the Y-axis secondary coils 38 (see Figure 2). The pick-off support 32 thus requires three sets of coils to be preformed; one set of primary coils 34 (Figure 7), and two sets of secondary coils 36;38 (Figure 8). All the sets of coils are made in a similar way as described above. In Figures 7, 8 and 9 the direction of winding the coils is indicated by the arrows.

Having assembled the primary and secondary pick-off coils 34, 36 and 38 onto the pick-off support 32, the two free ends of each set of coils are soldered to respective terminals 46 on the printed circuit board 43 (Figure 6).

The torquer coils 40;42 (Figures 9 and 10) are formed as an X-axis torquer pair and a Y-axis torquer pair using a former and a wire with a self-bonding resin coating, in a similar manner as the pick-off coils and have an arcuate shape to fit around the outside of the pick-off support 32. The free nds of each pair of torquer coils are soldered to respective

terminals 46 on the printed circuit board 42.

The unit as constructed so far is then assembled into a moulding fixture. The mould is filled with resin 48 under pressure (see Figure 3). After curing of the resin 48, the completed assembly is removed from the mould and subjected to in-process conditioning before assembly to the gyroscope main body.

CLAIMS :

1. A dynamically tuned gyroscope including:
a rotor mounted for spinning about a spin axis; and
a position detector for detecting tilting movement of the rotor about axes orthogonal to said spin axis,
said detector comprising a pick-off support means having a generally ring-shaped main body portion integrally formed with a plurality of pole piece portions projecting therefrom at spaced positions around the main body portion, each of said pole piece portions facing said rotor and having associated therewith a respective coil.

2. A dynamically tuned gyroscope according to claim 1, wherein said pick-off support means is formed using an electrodischarge machining process.

3. A dynamically tuned gyroscope according to claim 1 or claim 2, wherein said pick-off support means comprises a castellated ring.

4. A dynamically tuned gyroscope according to any preceding claim, wherein said pick-off support means includes eight pole piece portions, alternate pole piece portions having associated therewith the primary coils of a differential transformer, and the intermediate pole piece portions having associated therewith respective secondary coils for sensing movement of the rotor about a first axis and a second axis orthogonal thereto.

5. A dynamically tuned gyroscope according to any preceding claim, wherein, before assembly with the pick-off support means, each of said coils is preformed by winding on a former and causing at least some of the turns of the coil to become bonded together.

6. A dynamically tuned gyroscope according to claim 5, wherein

said coils are made using wire with a self-bonding coating.

7. A dynamically tuned gyroscope according to claim 5 or claim 6 when dependent on claim 4, wherein all of said primary coils are preformed by winding a single length of wire on a former including four coil formers.

8. A dynamically tuned gyroscope according to claim 7, or claim 5 or claim 6 when dependent on claim 4, wherein each pair of secondary coils is preformed by winding a respective single length of wire on a former including two coil formers.

9. A dynamically tuned gyroscope according to any preceding claim, which includes a printed circuit board of generally annular form positioned around the main body portion of the pick-off support means, the free ends of the coils or groups of coils being connected to terminals on the printed circuit board.

10. A dynamically tuned gyroscope according to claim 9, which further includes a plurality of torquer coils each with the plane of the coil being curved to be arcuate, and each being located radially outwardly adjacent the main body portion of the pick-off support means, the free ends of the torquer coils being connected to terminals on the printed circuit board.

11. A dynamically tuned gyroscope according to claim 10, wherein the torquer coils are made by winding on a preform and causing at least some of the adjacent turns of the coils to become bonded.

12. A dynamically tuned gyroscope according to claim 10 or claim 11, wherein the torquer coils, the printed circuit board and the pick-off support means are bonded together by a curable resin material.

13. A method of making a dynamically tuned gyroscope including a rotor mounted for spinning about an axis and a position detector for detecting tilting movement of the rotor about axes orthogonal to said spin axis, which method includes the steps of:

integrally forming a pick-off support means having a ring-shaped main body portion and a plurality of pole piece portions projecting therefrom at spaced positions around the main body portion;

preforming a plurality of coils; and

assembling said coils on said pole piece portions to provide said position detector.

14. A dynamically tuned gyroscope substantially as hereinbefore described, with reference to, and as illustrated in, any of Figures 2 to 10 of the accompanying drawings.

15. A method of making a dynamically tuned gyroscope, substantially as hereinbefore described with reference to any of Figures 2 to 10 of the accompanying drawings.

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